Title: Autoregulated adjustments of intensity optimises maximal strength over a 12-week training cycle.

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Abstract

The strategy of autoregulation (AR) is not a novel approach from a practical perspective, however, regarding research there exists a limited number of studies. The majority of literature has demonstrated the effectiveness of AR in rehabilitation patients with a focus on manipulation of training volume. The purpose of this study was to determine the effect of AR intensity on 1 repetition maximum (1RM) of front squat (FS) and back squat (BS) in resistance trained males (training age +2 years) following a 12-week strength programme. For the purpose of comparison, a second subject group followed a previously established 'traditional block' (TB) strength programme. Each group participated twice weekly in either an AR or TB programme [AR: n=15; 27.9 ± 5.3 years, TB: n=16; 28.3 ± 5.6 years]. Pre and post 1RMs were tested at the start and on week 13. The FS and BS 1RMs improved significantly within each programme (all $P<0.05$). The magnitude of improvement was significantly greater in the AR programme (time x group interaction) 0.004 and 0.006 respectively. Additionally, a significant difference was found between AR and TB group ($P<0.05$) for week 12 training intensity relative to post 1RM, with the AR group displaying greater training intensities. The results from our cohort indicate that AR training is effective in eliciting greater strength adaptations across 12 weeks. It can be concluded that AR adjustments of intensity, made on a set to set and session basis can optimise maximal strength gain throughout a 12-week training cycle.

KEY WORDS: autoregulation, block periodisation, 1RM, repetitions in reserve, RPE

CHAPTER 1

Introduction

Maximal strength is an essential component in optimising athletic performance and has been proven to enhance endurance running, soccer and sprint cycling. (2, 7, 18, 33, 34, 36). Strength and conditioning (S&C) practitioners have long been concerned with optimising strength training methods, and it is generally accepted that periodised programming is greater in eliciting strength gains than non-periodised (28). Periodisation is defined as the planned distribution of training to increase the potential for achieving optimal sports performance at a predetermined time point (32). Current knowledge suggests that strength and power are effectively improved by a phase, block method (6, 19, 35). Block periodisation was first proposed by Verkhoshansky (35) and is a model based on several mesocycles, each with a distinct training stimulus. The mesocycles are performed in a logical order, whereby the previous block prepares the athlete for subsequent blocks. These mesocycles include hypertrophic, basic strength and maximal strength phases (6, 19, 35). The model is marked by a constant increase in intensity with a decrease in training volume across the mesocycles (4).

Autoregulation via a means of adjusting the variables of training is not a new approach in S&C practice, however, is a less commonly studied form of periodisation, with limited current research (23, 31). Autoregulation enables adjustment to a strength programme based on an individual's readiness to train on a daily or weekly basis (23). Due to individuals adapting to training stimuli at different rates, it has been proposed that autoregulated training may result in greater strength gains when compared to a traditional programme (23).

Successful application of AR training has been noted in both physiotherapy patients and collegiate athletes (10, 21, 23). In both cases, researchers utilised the "progressive resistance exercise system" (PRE) first outlined by Delorme et al. (10). In 1948 DeLorme (10) designed a programme for rehabilitation patients consisting of resistance exercises with progressively heavier sets of 10 repetitions which was named "Progressive Resistance Exercise" system. The PRE system had participants performing 1 set at 50% of the patient's 10RM, 1 set at 75%, and finally 1 set at 100% of 10RM. Knight et al. (21), further developed the PRE by adding an autoregulated set to account for daily responses to patient's rehabilitation programme. Mann et al. (23) constructed a similar design to DeLorme whereby a set number of repetitions were performed at a percentage of the 10RM, 6RM, and 3 RM. Mann et al. (23) allowed the collegiate athletes to self-adjust the weight based on the third set performance. For example, during the third set subjects performed a maximum number of repetitions until failure with 100% of the anticipated 6RM. The load for the fourth set was subsequently increased or decreased depending on the number of repetitions achieved in the third set. All studies proved to be effective in increasing maximal strength. However, a limitation of Mann's study was that the two programmes had a different volume scheme and were performed one year apart. The outcome of the study showed that AR programming was more effective in increasing bench press and squat strength over 6 weeks compared to the linear periodised model (23). Although, the results from this study may have been subject to influence by the numerous independent variables that were not held constant between the two testing and training protocols (volume and intermittent training history).

McNamara and Stearne (24), attempted to equate total volume of training between the AR group and nonlinear group twice weekly for 12 consecutive weeks while manipulating the intensity of training for both groups. Authors found that AR training significantly increased

leg press scores in beginner weight trainers compared to non-linear periodisation. The AR group was instructed to choose between 3 workouts of varying intensities depending on how motivated, and energetic they felt before each session (10-, 15- or 20- repetitions of various free weight exercises). A limitation of this study design arose in that the AR group had fewer choices of intensity towards to final weeks of the programme because of the necessity to equate volume for both programmes and therefore the ability to self-adjust was limited by this. Although this study showed a significant outcome, the fact that both groups were beginners may have accentuated the results with evidence that novice athletes exhibit rapid strength improvements through neural factors such as intramuscular coordination and motor unit firing (16, 22). Thus, there is a need for further research to be conducted with experienced resistance trainers to observe if similar gains in strength are elicited.

Aside from volume of training the autoregulation of other training variables has been successfully demonstrated in previous literature (10, 21, 23, 24, 31). Goessler and Polito (11), successfully demonstrated the effectiveness of autoregulation of rest intervals in resistance trained men compared to fixed rest periods, resulting in a greater performance outcome in the AR group. Previous literature has proven AR as an effective training modality for improving maximal strength in exercises such as bench press, back squat and various free weight exercises (23, 24). The back squat movement has been noted to be key to improving force production (20), which is a determinant of sporting performance. Gullet (12) observed that muscle activation during the front and back squat was similar, with slightly greater quadriceps and erector spinae activation in the front squat. In S&C practice, the front squat is a prevalent exercise due to its role in joint health, through lower levels of shearing forces imposed on the lumbar spine (verses back squat) (9, 12, 26).

There exists a wealth of scientific literature promoting the importance of periodisation. However, the most effective manipulation of training variables is yet to be determined.

The studies presented above have shown that there is need a for a more robust study design that holds its dependent variables constant between groups while manipulating one variable to show its effect on performance outcome. The choice of manipulation for this study was the intensity of training due to the prevalence of literature that has shown effective in manipulating rest intervals and volume to elicit strength gains. Previous studies of

adjustments made to intensity, have demonstrated limitations in study design, whereby participants were unable to accurately self-adjust intensity due to diminishing choices of exercise regime (24). The intensity of training was subjectively determined through the idea of 'repetitions in reserve' (RIR), i.e. how many more repetitions the participant feels able to perform with a given load at the prescribed volume. It is suggested that RIR will enable athletes to accommodate for the variation in external variables such as sleep, nutrition, and life stress, allowing the intensity to be reactive to daily changes in performance capabilities. The RIR method accounts for these daily changes because of its more flexible nature, allowing the participant to perform at lesser or greater intensities as would be prescribed by a traditional method. The RIR aims to prevent participants from over exertion with the knowledge that repetitions must be left in reserve for every set.

The purpose of this study is to optimize maximal strength as measured by 1RM front and back squat performance. For the purpose of comparison two schemes of intensity adjustments were prescribed to the two study groups (AR and TB). The main aim was to manipulate one narrowly defined variable (intensity) to elicit greater improvements in maximal strength and provide a rational use for AR programming to further the S&C practice. It is hypothesized that over a 12-week duration the AR programme will result in a greater improvement in measures of maximal strength in comparison to a traditional training block periodisation. The authors believe the reason for this hypothesis is because the intensity will be greater within the duration of 12 weeks for AR group.

CHAPTER 2

Methods

An experimental approach to the problem:

The study was a randomised clinical trial and was registered with the Randomised Clinical Trial Registry. This step was taken to prevent a bias in the selection procedure and ensure against the accidental bias. The study required quantitative data measuring the pre- and post-intervention 1RM in two strength training modalities (front and back squat).

The initial testing day was utilised to collect each subject's anthropometric data (age, height, and body mass) and 1RM in BS and FS using previously reported methods (1, 13, 20, 37). Following the initial familiarisation day and pre 1RM tests, data was collected and stored in a Microsoft Excel spreadsheet. The participants were randomly assigned using a random number generator function in Microsoft Excel. Participants were allocated one of two training programmes to adhere to for a 12 week period (traditional block; TB group or autoregulated; AR group). The testing took place at a privately owned Strength and Conditioning facility in Northern Ireland, County Down.

Participants

Thirty-one participants experienced strength trained males who engaged in resistance exercise at least twice per week for more than two years. Participants were required to meet the following inclusion criteria to be involved in this study; aged 18-36, 69-95 kg bodyweight. A prerequisite of participation was the ability to execute both FS and BS correctly as per the coach's discretion. Participants were required to show technical competency in FS and BS in accordance with protocol derived from Baechle and Earle (1) shown in the appendix. On the initial testing day if the participant was not able to meet this criteria then the participant would be excluded from the study. It was important that the

author (TG) observed each participant dismounting the bar safely for both FS and BS. This was to accommodate for any need to lose the bar throughout the testing and the 12-week programme. Participants worked through the programme independently and were not supervised to the duration of the programme with adherence monitored by a weekly email. Both experimental groups were comprised of strength and power-trained athletes actively training in various sports including soccer, Gaelic football, golf, field hockey, track and field, powerlifting and weightlifting. All participants were not prohibited from continuing sports specific training out with the study, which did include resistance training such as, bench, snatch, clean and jerk. There was no significant difference (P>0.05) between pre-test comparisons of participant height, body mass, and age. Furthermore, pre-test comparisons confirmed that there were no significant differences in baseline FS and BS 1RMs, age, height and body mass between the two groups (P>0.05). Participants were randomised into 1 of the following 2 groups shown in Table 1. All participants signed a study consent form and a PAR-Q document, and the study was approved by St Marys University ethics committee.

	Traditional Block (n = 16)	Autoregulated (n = 15)
Age (years)	28.3 ± 5.6	27.9 ± 5.3
Body Mass (kg)	82.5 ± 8.9	83.2 ± 9.7
Height (cm)	177.8 ± 6.5	179.6 ± 6.5
1RM Front Squat	111.3 ± 19.6	120.7 ± 26.3
1RM Back Squat	129.1 ± 21.3	141.2 ± 29.4

Table 1.

Testing Protocol

Participants followed the same warm up for each testing day which included light stretching, foam rolling, and resistance exercises including 2 sets of 10 repetitions each of goblet squats, lunges, and scapular push ups, followed by a 1 minute-rest. The following 1RM protocol was derived from Baechle and Earle (1). The participant performed a set of 10 repetitions with the empty barbell (20kg) with a 1 minute- rest. A conservative load was then estimated that allowed the participant to perform 3-5 repetitions by adding 10-20% 1RM. A 2 minute rest period was provided. An estimated load was then chosen that allowed completion of 2-3 repetitions followed by 2-3 minutes rest. Further load increases were made (10-20% 1RM) and participants were instructed to attempt 1 repetition followed by a 2-4 min rest. This was repeated until a 1RM was achieved or until failure. The participant was allowed a maximum of 3 attempts at the 1RM until failure or evidence of a deterioration in technique (13). FS 1RM was tested first, followed by a recovery of 10 minutes before the same protocol was performed for BS 1RM. Monitoring of safe and accurate technique was performed in front of the National Weightlifting Coach for Northern Ireland and a UKSCA accredited coach. The pre and post testing remained the same to ensure every participant was familiar with the protocol and the results of new 1RMs would be accurate comparing to the pre-test.

Resistance Training Protocols

The 12-week resistance training programme for each group can be seen in Table 3. All participants exercised 2 days per week with at least 48 hours recovery recommended between sessions, and the exercises performed were the same for each group. The groups differed only in the intensity (AR group were instructed to subjectively choose a load based

on RIR for each session which may have corresponded to a lesser, equal or greater than the intensity prescribed to the TB group).

Participants recorded all their results, in kilograms, for each session for FS and BS. Additional feedback was recorded on how they felt in a logbook to monitor adherence to the programme. The participants were required to record their rate of perceived exertion (RPE) for each set; this was collated at the end of the programme study and averages were calculated to give an average RPE for each session performed. The TB programme consisted of three mesocycles, each with 4 weeks in duration, with decreasing training volume and increasing intensity. Each mesocycle progressed from hypertrophy to basic strength to a maximal strength phase.

The TB group received explicit instruction regarding the volume and intensity of each session. The intensity prescribed to the traditional block group was derived from Baechle and Earle (1), who presented a table of estimated repetitions that can be performed at a percentage of one repetition maximum (1RM) (see Table 2). An outline of sets and repetitions prescription is detailed in Table 3.

The AR group completed the same programme as the TB group with the same number of sets and repetitions prescribed for each session. However, the intensity was not disclosed, the AR group were instructed to determine the load subjectively for each set and session. The participant was required to choose a load that related to the feeling of having a required number of RIR. The AR procedure of RIR is referenced in Table 2. Thus the participant chose a load (kg) to perform the necessary repetitions (10, 5 or 3) with a further 4, 3, 2 or 1 RIR. For example, sets prescription was given with a subjective feeling of having "4 RIR". Thus, the athlete could perform a further 4 repetitions if required to, but unknown to the athlete what the intensity was until the set is completed on that particular day (see Table 3).

Percentage 1RM	Number of Repetitions Allowed (1 set)	Sets and Repetitions	AR Repetitions in reserve
100	1		
95	2	3x3	MAX
93	3	3x3	0
90	4	3x3	-1
87	5	3x3	-2
85	6	4x5	-1
83	7	4x5	-2
80	8	4x5	-3
77	9	4x5	-4
72	10	3x10	-1
70	11	3x10	-2
67	12	3x10	-3
65	15	3x10	-4

Table 2

Programme Variable	Phase 1 (WK 1- 4)	Phase 2 (WK 5-8)	Phase 3 (WK 9-12)
TB: Training Intenisty (%)	65, 67.5, 70, 72.5%	77.5, 80 82.5, 87.5%	87.5, 90, 92.5, 95%
AR: RIR	4, 3, 2, 1	4, 3, 2, 1	2, 1, 0, MAX
Training volume (repetitions)	3 x 10	4 x 5	3 x 3
Rest Time	2-3 mins	2-3 mins	2-3 mins
Day 1	Front Squat		
Day 2	Back Squat		

Table 3.

Statistics

Statistical analysis was performed using SPSS (version 22, Armonk, NY: IBM Corp) Pre-test comparisons of participant characteristics were performed using a one way ANOVA. A repeated measures ANOVA was used to test for differences in front and back squat improvement, the between participants factors were training group (AR or TB) and the within participants factor was time (pre and post-test scores). Further repeated measures ANOVA were performed for changes in body mass within and between groups. Following a significant interaction, post hoc analysis included a paired sample t-test to determine within subject effects, while a one-way ANOVA was utilised for the between subject effects. Repeated measures ANOVA was also used to determine if there was a difference between the groups' final week of training intensity as a percentage of the pre 1RM and relative percentage of the post 1RM. A Repeated measures ANOVA was used to determine the difference between the phases in the two groups (AR and TB) over 12 weeks in RPE ratings. All values are expressed as a mean $\pm$ standard deviation unless otherwise stated. The level of probability was set at 95% ($P<0.05$). Main effect for Time indicates a difference between pre vs post values (pooled AR and TB, $P<0.05$). Effect sizes were quantified by the calculation of partial η^2 and are interpreted as the difference between the two group's means. An alpha level of $P <0.05$ was set for all testing.

CHAPTER 3

Results

Subject Characteristics

No significant time x group interaction effect was observed for pre and post-test body mass ($P \geq 0.05$). However, there was a main effect for time (pooled group pre vs. group post data; $P < 0.05$), demonstrating that fat-free mass increased over the 12-week programme (but not selectively between groups).

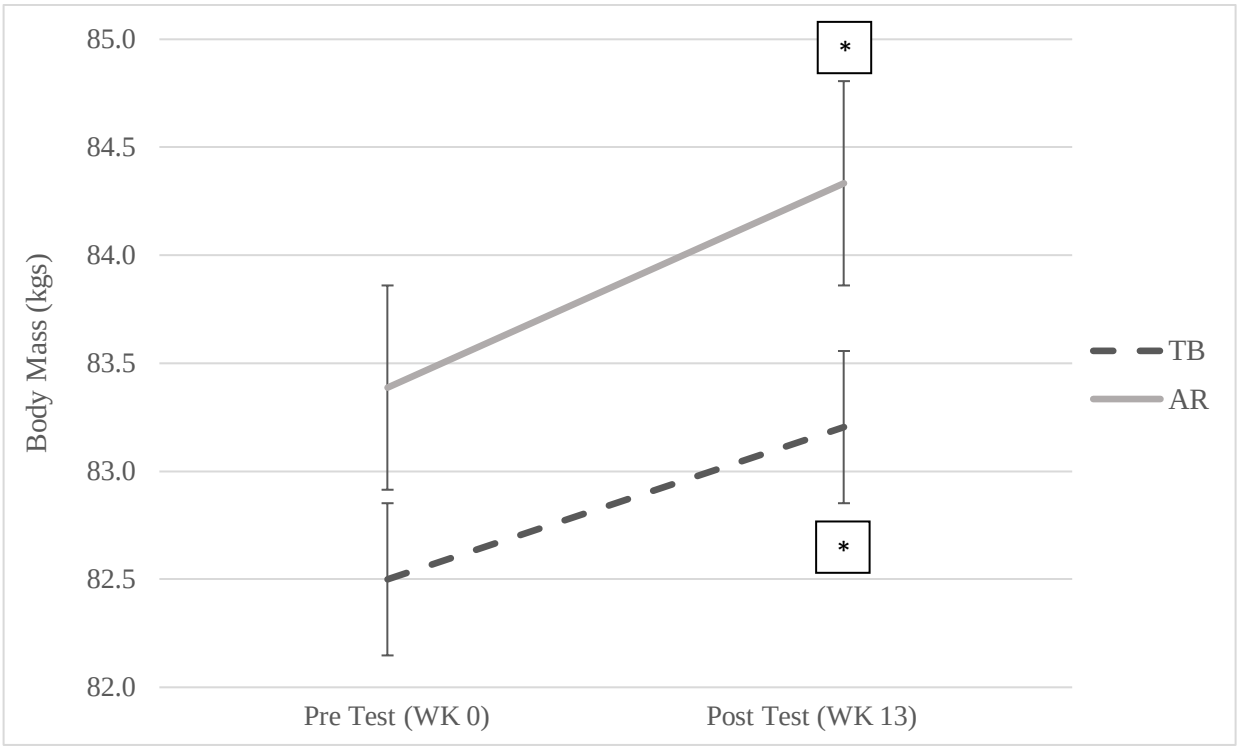

Figure 1. *different to pre ($P < 0.05$).

Pre and Post 1RM

There was a time x group interaction effect for AR and TB programmes on 1RM squat performance (see Figures 2 and 3). The post hoc test showed a difference within group interaction for FS and BS with significant increases in both AR and TB ($P<0.05$). The effect size for the AR group equaled η^2 0.26 for FS and η^2 0.23 for BS, which indicates a large effect size according to omega-squared interpretation guidelines. For the time x group effect, 26% (FS) and 23% (BS) of the total variance in 1RM scores can be accounted for by the group x programme effect. AR training group resulted in greater increases in maximal strength performance than TB. Figures 2 and 3 demonstrate the larger increase in FS and BS strength in the AR group versus TB.

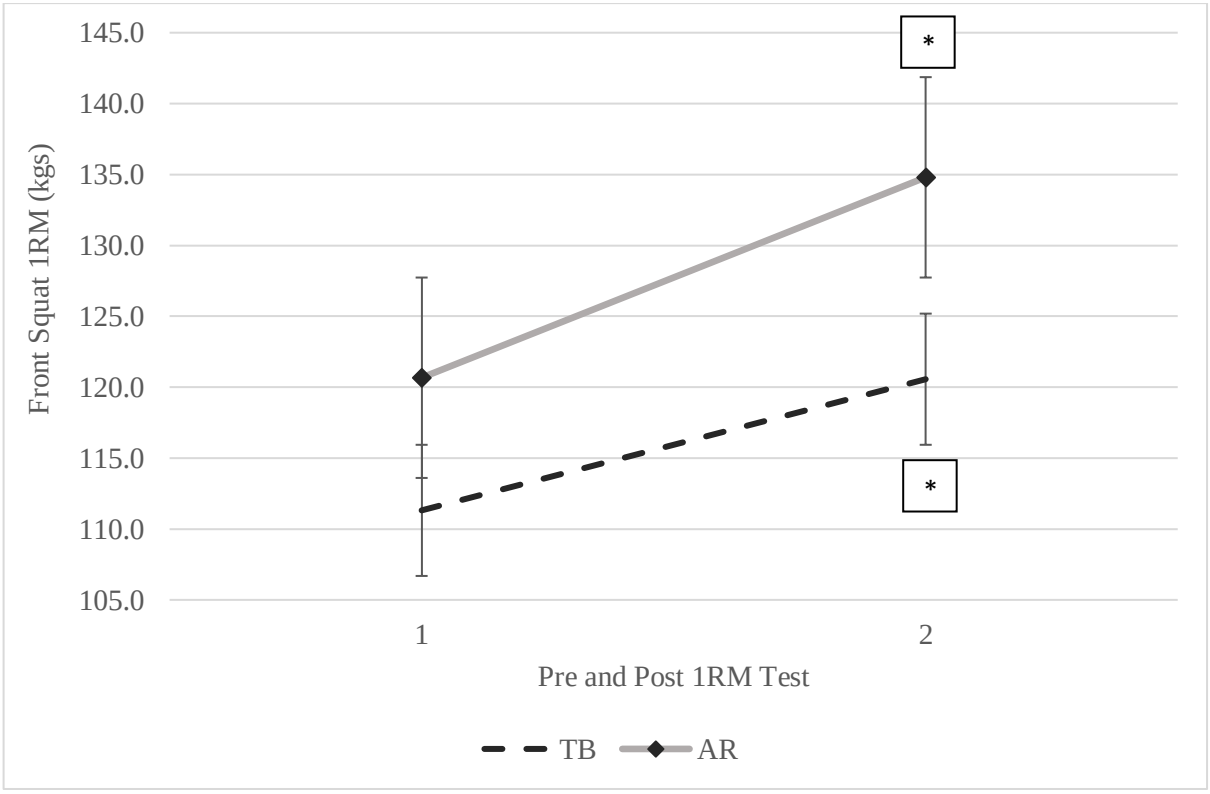

Figure 2. *different to pre ($P<0.05$).

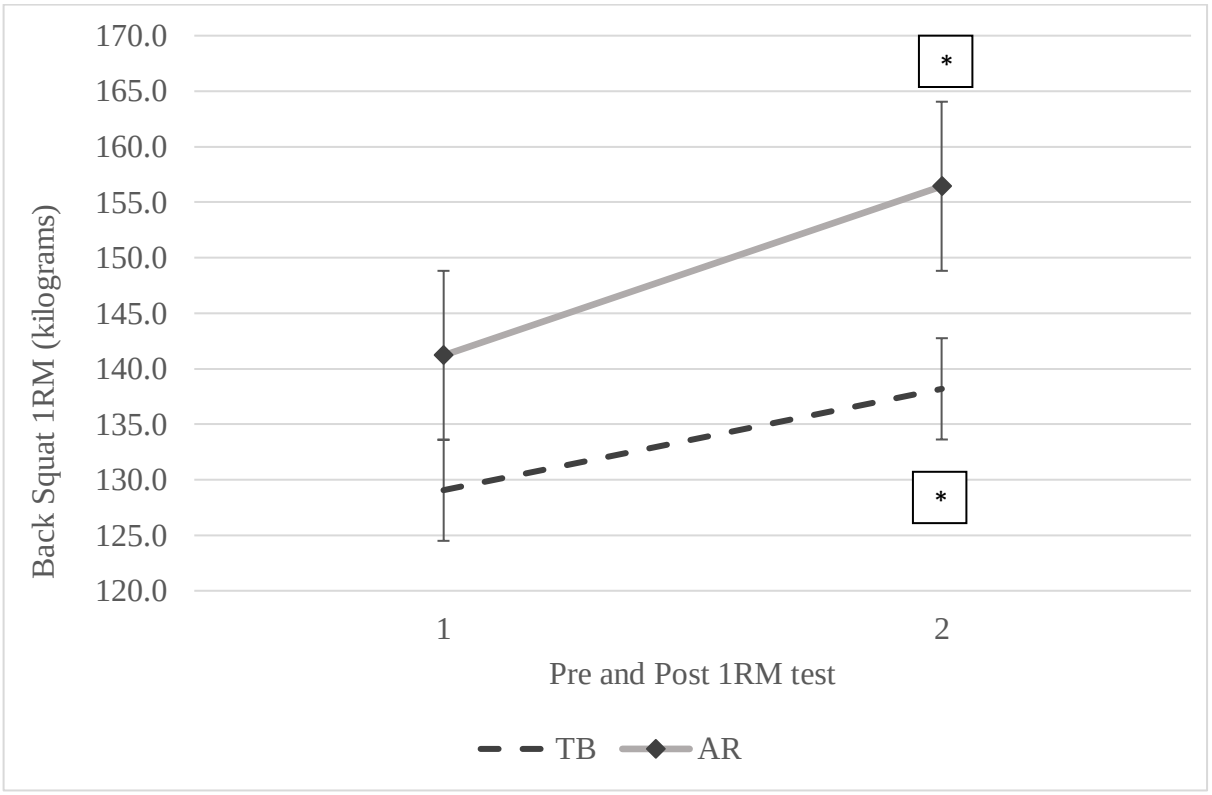

Figure 3.

*different to pre (P<0.05).

Training Intensity

Figure 4 shows the weekly average FS and BS training intensity (%1RM) for AR and TB groups. No significant difference was detected between the two groups (P>0.05). The first 4 weeks the intensities were relatively matched. Although, week 5-8 the intensities for AR were greater in comparison to TB. Additionally, the AR group BS was considerably higher percentage than FS AR. Week 9-12 there was a continual steady increase in average FS AR. The AR BS demonstrated a slight reduction in comparison to the rate of increase observed in weeks 5-8.

Furthermore, data analysis revealed a difference between the two groups when the final week's training intensity was made relative to the post 1RM. Table 4 shows the intensity of training on week 12 relative to the pre-1RM and post-1RM for FS and BS. A difference was detected ($P<0.05$) between AR and TB groups, with the AR group presenting a higher training intensity (%1RM) in the final week relative to their new 1RM scores. The effect size for FS was $\eta^2=0.33$, and BS was $\eta^2=0.36$. These are considered large effect sizes, meaning that 33% (FS) and 36% (BS) of total variance of week 12 relative intensity were accounted for by the independent variable (time x programme). This observation supports previous findings that the incremental loading for the AR group was greater than TB for the duration of the study, which resulted in higher training intensities in the final 4 weeks. The AR group demonstrated increases of more than 2.5% each week, resulting in supramaximal %1RM relative to pre 1RM on week 12.

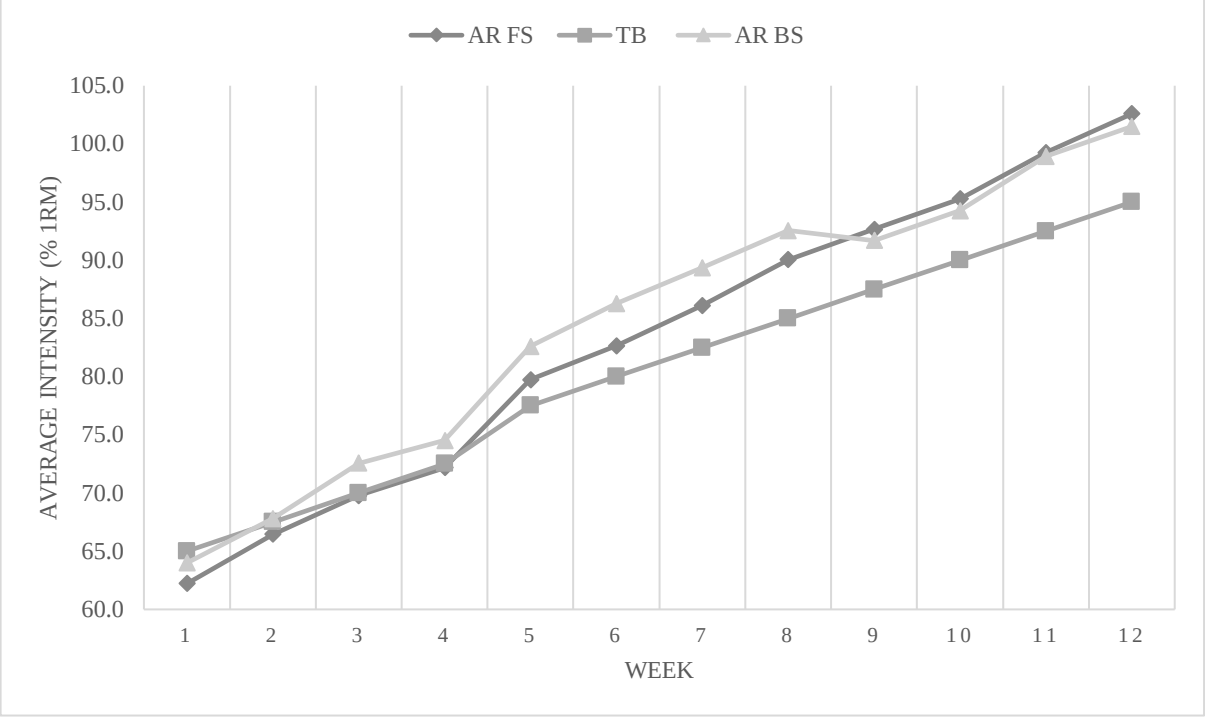

Figure 4.

Front Squat

		Pre-test		Post-test		Difference	
Group	*N*	kg	(SD)	kg	(SD)	Absolute	Relative(%)
AR	15	120.66	26.32	134.8*	26.09	14.14	11.72
TB	16	111.31	19.57	120.56	18.29	9.25	8.31

**difference to TB*

Time x group *P*=0.004, ɳ2 0.26

Back Squat

		Pre-test		Post-test		Difference	
Group	*N*	Kg	(SD)	kg	(SD)	Absolute	Relative(%)
AR	15	141.2	29.8	156.43*	29.8	15.23	10.79
TB	16	129.06	21.3	138.18	19.5	9.12	7.07

**difference to TB*

Time x group P=0.006, ɳ2 0.23

Week 12 FS Intensity Relative to Post 1RM

		% Pre-test 1RM		% Post-test 1RM	
Group	*N*	%	(SD)	%	(SD)
AR	15	102.60	7.60	90.49*	5.43
TB	16	95.00	0.00	84.93	7.34

Time x group *P<0.05*,η^2=0.33
**difference to TB*

Week 12 BS Intensity Relative to Post 1RM

		% Pre-test 1RM		% Post-test 1RM	
Group	*N*	%	(SD)	%	(SD)
AR	15	102.58	7.57	90.89*	3.85
TB	16	95.00	0.00	87.33	5.87

P<0.05,η^2=0.36
**difference to TB*

		Mean RPE rating			
		Pre-test RPE Front Squat		Post-test RPE Back Squat	
Group	*N*		(SD)		(SD)
AR	15	7.75	0.9	7.90*	0.89
TB	16	6.95	0.91	6.43	1.05

**difference to TB (P<0.05) η^2= 0.6*

Back Squat

Front Squat (P>0.05)

Table 4.

RPE Rating

The average RPE rating showed significance with the AR group recording higher values than the TB group (BS <0.05 but not for FS >0.05). The effect size for BS RPE was η^2=0.6, indicating a large effect size, and that 60% of the variance of RPE scores is accounted for by the time x programme effect. On average AR group displayed higher RPE's for the duration of the 12-week study. Table 4 shows the average RPE feedback for FS and BS sessions across the 12 weeks of TB and AR training programmes. Similar trends have been shown in intensity with the BS showing significantly higher results compared to the TB. As the intensity of training increased so did the average RPE that was reported.

CHAPTER 4

Discussion:

The results of this study indicated that both the AR and TB groups showed a significant enhancement in 1RM FS and BS performance. The AR group showed a greater improvement in post-test scores. The magnitude of gain in for the AR group was greater than the TB group (η^2 0.26 FS and η^2 0.23 BS). The AR group increased 1RM FS by 14.14kg in comparison to 9.12kg for TB group and equally in BS AR increased by 15.23kg compared to 9.12kg. In both cases was a 3.5% difference from pre to post 1RM tests. This confirms the hypothesis that over a 12-week duration, the AR programme would result in a statistically significant improvement in maximal strength performance. Therefore, implementing an AR programme that permits intensity adjustments above or below a fixed traditional prescription optimises the rate of strength adaptations in experienced resistance trainers.

No statistical difference was found when comparing AR and TB intensities across the 3 phases. However, Figure 4 demonstrates that in the latter two phases of the programme AR intensity of training for the FS & BS was higher than that of the TB group. The AR group were not limited to a 2.5% increase in load each week and on the whole demonstrated greater incremental loading throughout, owing to the performance of the previous 1RM for repetitions on week 12. It can be assumed that the AR group experienced a greater training stimulus throughout that closely mimicked the intended outcome of this study (maximal strength performance). It was observed that AR participants were able to tolerate greater adjustments in training intensity and thus the AR group demonstrated greater strength improvements throughout the duration of the study compared to the TB group.

During the 2nd phase (weeks 5-8) BS intensity increased considerably more than the rate at which the TB group performed. It was apparent that having completed the higher repetition ranges of phase 1 (weeks 1-4) the participants were able to commence phase 2 (4 sets of 5 repetitions) at a higher intensity of loading. One assumption could be that the participants may have been more accustomed to performing a 5 repetition range from previous training experience and therefore were able to gauge loads more effectively. Thus the AR group may have been encouraged to achieve a higher intensity with their allocated RIR. This observation shows that tables like that of Baecle and Earle's (1) act as a guideline to prescribing repetitions, however practically athletes can achieve more repetitions at a higher intensity than what is allocated. For instance, for one set at 85% 1RM, 6 repetitions are deemed achievable by a fixed table (1).

However, in week 8 the TB group performed 85% 1RM for 4 sets of 5 repetitions. The AR exceeded this intensity in week 8, performing the FS with 90% and BS 91% for 4 sets of 5 repetitions. This suggests that working at a higher intensity imposes greater neural and mechanical stressors, ultimately resulting in optimal adaptations and subsequent strength performance. The SAID (Specific Adaptation to Imposed Demands) principle states that training should closely mimic the intended performance outcome (20). Thus, squatting at a higher %1RM, the AR group applied more stress to the body and following adaptation the participant was able to achieve a further increase in intensity in the following week's training.

Furthermore, a significant difference was observed when the final week intensity of training was made relative to the post-test 1RM. AR group demonstrated a greater %1RM for both FS and BS in week 12 of the programme relative to post 1RM. This suggests the AR programme allows the rate of loading to increase beyond that of pre-determined %1RM (i.e. 2.5% each week). It could be projected from the final week training intensities relative

to post-test 1RM, that the TB group would require an additional 2 weeks of training to match AR week 12 FS %1RM (AR = 90.49 ± 5.43% vs. TB 84.93 ± 7.34%). Moreover, 1 additional week to match the intensity of the BS (AR = 90.89 ± 3.85% vs. TB 87.33 ± 5.87%). The AR attained an average intensity of 94% 1RM for 3x3 on week 9 (FS) and week 10 (BS), whereas TB group reached 95% 1RM for 3x3 in week 12. One reason for this is that AR allowed participants to choose an intensity that was higher in percentage than traditional through the cycle. The choice was based on the subjective measure of the number of RIR. More importantly, the main explanation for this was that AR accounts for the fact the participants get stronger through the study more so than TB.

Previous literature suggests that the interaction between muscle hypertrophy (cross-sectional area of muscles fibres) and neural adaptations (motor unit recruitment) result in enhanced strength performance (2, 14, 15, 38). An explanation for the significant increase in strength performance and fat-free body mass within the two groups (pre and post total 1RM) can be deduced from the equal volume performed by all participants. Volume (sets and reps) remained constant in both AR and TB groups, and it can be assumed that the hypertrophic adaptations resulting from training volume were equal between the groups (5, 32).

How the programmes differed was the adjustment of intensity in the AR group which can account for the steeper incline shown in Figure 4. The mechanism of how the intensity was determined was RIR. Helms et al. (17) suggested that participants were able to more accurately determine what intensity to work at when the RIR were at a lower number, i.e. 1-4 repetitions in reserve. This confirms the similar trend observed in this study, whereby as the RIR decreased, the intensity and subsequent RPE increased.

Although, a small factor within the participant feedback stated the programme was difficult to implement for the initial 2 weeks due to estimating the accuracy of RIR, particularly

with 3 x 10 repetitions with -4 and -3 RIR. As seen in Figure 4 the only week that intensity was not greater than TB was week one. This may suggest the AR participants were adjusting to the new training method of accurately estimating RIR. In some incidences, it may have taken 1-2 sets to complete to discover how many repetitions were in fact left in reserve. Although, when the RIR reduced to near maximal (-2,-1, 0) it was easier to implement and participants became more accustomed in gauging the RIR as the programme developed. This is supported by Zourdos et al. (39) who stated that more experienced lifters were better at gauging the number of RIR and become more accurate when loads were near maximal, and RPE was higher.

On average AR group displayed higher RPE's for the duration of this study. Thus, RPE increased as the RIR became less showing the validation of Borg's (8) scale for AR is effective. A significant difference was found between the 2 groups for BS ($P<0.05$). Although, there was no difference was found in FS RPE ($P>0.05$) in comparison to TB. Subjective feedback from study participants stated that leg strength was not the perceived limiting factor for FS performance, but the ability to maintain the integrity of the thoracic spine. This suggests that FS performance may have been limited by the necessary technical execution in maintaining an upright posture, thus restricting any significant deviation from the intensities prescribed by traditional %1RM and the subsequent RPE ratings. At the higher intensities, excessive trunk inclination may have caused a shift in weight distribution off the centre of mass and greater difficulty in completing the lift (16).

The BS has been shown to be less technically demanding, with the bar positioned on the centre of the shoulders and supported by the full body weight underneath the bar weight (37). This suggests that greater incremental loading could have been accommodated for in the BS, owing to the AR group demonstrating greater intensities and RPE scores for the duration of the study.

The literature states that to increase maximum strength, experienced strength trained athletes should incorporate high intensity and low volume training to increase maximum strength (22). Peterson (25), defined low volume as 6 or less per set accommodating training at 85% >1RM. Incorporation of 1-3 reps above 90% will result in strength gains (30). AR participants showed a higher rate of progressive overload than TB group with the AR the majority of the group achieving the previous 1RM for repetitions within the programme.

CHAPTER 5

Limitations

The TB group could only achieve 95% 1RM within the programme which was in fact 84.93% ± 7.34 of the FS post-test 1RM and 87.33% ± 5.87 of post-test BS 1RM. Limitations to percentage 1RM-repetitions tables arise from the assumptions that it is based on. One assumption is that the association between repetitions performed and load lifted is linear not accounting for any external stressors and its effect on performance (3). Further limitations highlighted by Richens and Cleather (29), in that individual variations exist in the number of repetitions that can be achieved at a given percentage 1RM. This concern was demonstrated within the results of this programme, whereby the AR group were able to achieve repetitions beyond that which were recommended by the fixed tables (1).

With regards to the AR programme design, participants reported that accuracy in gauging RIR was initially difficult, particularly when RIR numbers were greater (-4,-3) and volume was higher (3 sets and 10 repetitions). This was apparent in the initial two weeks were the training intensity did not differ between groups. Furthermore, subjective reports from AR participants stated confusion in the final block of the programme when required to differentiate between effort for '0' RIR and a 'maximum.' Future studies should redefine these RIR efforts in order to clearly brief the participant as the intended intensity outcome of the session. Week 11 was intended to be a maximum for effort for 3 sets of 3. The following week 12 was to be another maximum effort session, with the intention that intensity of training was slightly higher than that of the previous week to match the previous incremental loading trend.

Further to the study design, a limitation was the participants were involved in other sports such as powerlifting and weightlifting alongside the study. Although no other squats were

performed out with the study, the lack of external control meant that external variables might have influenced the outcome of this study.

The participants of this study were not supervised during sessions, and thus the possibility that a motivated participant would over exert to achieve intensities above that do not accurately represent RIR. Conversely, an under motivated athlete could have the opposite effect with intensity being lower than what is equivalent to true RIR.

Future research should look at monitoring the athlete on subjective feel. There is a need to determine if an athlete is over or under exerting. The physiological markers (creatine kinase, reduction in force output and heart rate variability) of fatigue need to correlate with the psychological markers (mood state, RPE, cognitive reaction time). As a result, the strength and conditioning practitioner will be able to determine if the athlete is accurate when selecting the intensity relative to readiness daily variations.

CHAPTER 6

Summary

There was a significant time x group interaction effect that demonstrated the AR group had a greater magnitude of FS and BS 1RM maximal strength gain than the TB group across the 12 weeks. The subjective idea of RIR has been shown to be valid in allowing the participant to be more reactive to daily variations in performance capabilities.

Additionally, the AR group reported a significant difference when the final week's training intensity was calculated as relative to the post-test 1RM. Through the phases of the block linear model, AR and TB groups showed significant adaptation from resistance training. Body mass increased equally between both groups suggesting hypertrophic gains are brought about by the volume structure of block linear model.

Although, because the AR group had the ability to manipulate the intensity they were able to increase by greater than 2.5% each week. On average, AR performed at a higher intensity over the 12 weeks. The RPE values for the BS across the 12 weeks confirmed the greater progressive overload for the AR group, with significantly higher RPE values reported for the BS than TB group, suggesting greater training intensity. Therefore, it can be concluded that neural adaptations (increased recruitment of motor units and enhanced neural drive) led to a significant difference in 1RM squat performance between AR and TB groups. AR can now be said to be as valid for S&C practice as TB method. More importantly, AR has proven to be more suitable for experienced athletes, as it requires the choice of intensity to accommodate individual responses to stressors and the ability to be more accurate when selecting the intensity relative to readiness daily variations. It is not always best practice to have a beginner athlete to complete a 1RM effort because of the

integrity of technique. Inaccuracy of the actual 1RM is prevalent in beginners, thus a % based programme may be imprecise. Future research should include to beginners with no previous experience in %1RM loading patterns, as to determine the efficacy of AR programme and the subsequent performance improvement.

CHAPTER 7

Practical Applications:

The findings from this study prove that using an AR programme can be more beneficial than using a TB periodised model to optimize strength gains. The load can be adjusted subjectively which differs from the TB method percentage increases. Additional monitoring using Borg's (8) RPE scale allows the athlete to adjust the intensity depending on their readiness to train.

Over a shorter duration, AR loading scheme supports a greater incremental increase in intensity across 12 weeks. Moreover, within the confines of the block volume loading scheme, AR were able to achieve higher intensities than TB over the same duration of time. Thus, it is recommended to utilize AR model when the opportunity to dedicate training to maximal strength is limited within a macrocycle. Future research should be conducted over a longer duration to determine whether any further significant difference between AR and the fixed incremental loading of TB is observed.

The RIR method of AR is a valid means of assigning daily training intensity that is not restricted by traditional loading schemes. In order to get a maximal strength stimulus in a minimal time frame, AR may be a better option because of the higher increments of loading.

The AR programme proved effective for all participants with previous resistance training experience. Thus this confirms that a need for previous experience in loading patterns and the subjective feelings of effort requirement at different loads is a desirable understanding for implementing an AR programme.

In response to the observation that the intensity of training in the initial 2 weeks of the programmes was similar between groups, it can be advised to implement a TB structure

in initial two weeks. This would also alleviate any of the subjective reports of uncertainty in load choice when the repetitions per set and RIR were high.

Finally, having observed that front squat did not support as great an incremental loading scheme as the BS, the authors can recommend that this AR method of intensity adjustments may be appropriate for use with simpler exercises to eliminate the impact of technique on performance.

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Appendix I

St Mary's University Twickenham London

SCHOOL OF SPORT, HEALTH AND APPLIED SCIENCES (SHAS)

Research / Dissertation / Project Approval Form – Page 1 of 2

This form contains all the necessary guidance and relevant information links to complete a Research, Dissertation or Project.

A: Research, Dissertation or Project General Information

Name:	TIMOTHY GRAHAM	Project Tutor/Supervisor:	DANIEL CLEATHER
Reg. no.:	134707	Contact number:	07894046995

Project Proposal title: DOES AUTOREGULATION TRAINING HAVE AN EFFECT ON SPRINT PERFORMANCE IN RESISTANCE TRAINED ATHLETES OVER A 12 WEEK CYCLE?

B: Application for Resources (Equipment and Consumables)

Establish the Research, Dissertation or Project cost, by referring to the costing guide located on the simmsCAPtial folder http://simmscapital.smuc.ac.uk/course/view.php?id=8401 . Please note that you must allow adequate time for the ordering and delivery of any approved consumables.

EQUIPMENT APPROVAL SUBJECT TO AVAILABILITY (LIST ALL INTENDED EQUIPMENT TO BE USED): | **APPROVAL SIGNATURE:** Technical Staff

CONSUMABLES APPROVAL (QUALIFYING CRITERIA):		**TICK**	**REQUIRED ACTION**	**APPROVAL SIGNATURE**
Option 1	Undergraduate project cost is less than £50 Post graduate project cost is less than £100		Option 1 can be signed by the Tutor/Supervisor.	Tutor/Supervisor
Option 2	The cost is more than the relevant funding limit as detailed in Option 1		Option 2 funding request £.....(inc.VAT)	Academic Director

Testing schedule must be agreed prior to RA and Ethics	**Tick**	
Category 1 – Normal hours (9-5) / daytime subjects		*Details of agreed Out of hours / non permitted equipment etc*
Category 2 – Apply for extraordinary testing circumstances		

C) Completion of a Risk Assessment (to manage all relevant Hazards)

A Practical Risk Assessment Form (PRA1) must be completed for all research, dissertation or project work. A completed PRA1 form will enable the commencement of laboratory or field testing, whether using human subjects (see Section D) or not. Please refer to Student information module on simmsCAPital for assistance, or alternatively contact your tutor or relevant member of the Technical Services Team.

QUALIFYING CRITERIA	**REQUIRED ACTION**	**APPROVAL SIGNATURE**
	REFER TO RISK ASSESSMENT.	
Any practical / testing activity	Complete a SHAS Practical Risk Assessment (PRA1) Form. Once completed, this Section can be signed off by a relevant member of the TS Team.	Technical Staff

Research / Dissertation / Project Approval Form – Page 2 of 2

D) Application for Ethical Approval (including the use of Human Subjects)

An **Application for Ethical Approval Form** must be completed for any Research, Dissertation or project to determine the ethical grading (Level 1, 2 or 3) and relevant approval pathway, as set out in the table below. For forms, guidelines and application dates please see: http://simmspace/about/academic-board/ethics-committee/Pages/default.aspx

	QUALIFYING CRITERIA	TICK	REQUIRED ACTION	APPROVAL SIGNATURE
Ethics Level 1	The protocol matches a School of SHAS Standard Lab Procedure with Ethical Approval		The protocol can be signed off by the relevant Tutor/Supervisor	Tutor/Supervisor
Ethics Level 2	The protocol does not match a School of SHAS Standard Lab Procedure with Ethical Approval	✓	The Application for Ethical Approval Form must be submitted to the School Ethics Representative.	Ethics Representative
Ethics Level 3	The Project is deemed to have an Ethics Level 3 status by the School's Ethics Representative.			

Additionally, specific forms must be produced for the use of all human subjects who are participating in physical activity, ingesting liquids/foods/supplements and / or receiving treatment, as set out in the table below.

QUALIFYING CRITERIA	TICK	REQUIRED ACTION:	APPROVAL SIGNATURE
All activities using human subjects	✓	Receive a Subject Information sheet., and complete an Informed Subject Consent form. See http://simmspace.smuc.ac.uk/prog-admin/Pages/ethics-and-integrity.aspx Complete a Medical History/ PAR-Q Form. See simmsCAPital http://simmscapital.smuc.ac.uk/course/view.php?id=8401	Tutor/Supervisor

All Consent and Screening Forms must be counter signed/dated and retained by (you) the test coordinator during the testing phase, and then returned to the Tutor/Supervisor for data protected archiving. The table below clarifies which forms are relevant and what action to take.

E) Competency training and authorisation to undertake specific testing activities

Approval to competently undertake the intended protocol(s) must be obtained through the student completing training, practice and passing an assessment . Specific approval forms may need to be completed. Tutors must attend the first pilot/testing session to jointly (tutor/student/technician) approve the relevant protocol and student competency. Please note that further practice may be required if competency cannot be demonstrated. Please see Technicians for more information.

ACTIVITY REQUIRING APPROVAL	RELAVANT INDUCTION OR FORM	APPROVAL SIGNATURES	
TECHNICAL MODEL OF FRONT SQUAT & BACK SQUAT.	COMPETENCY WAS MET ON MODULE ONE OF MSc PROGRAMME ASSESSMENT VIVA. UKSCA ACCREDITED.	Technician	Tutor/Supervisor

F) Research/Dissertation/Project declaration

In undertaking my Dissertation/Research Project, I agree to adhere to the approved guidelines and procedures for the protocol I am using, and will inform my supervisor of any necessary changes to my protocol.

DECLARATION SIGNATURE: T. [signature]

(Individual undertaking the relevant Research/Dissertation or Project)

DATE: 02/01/2017

St Mary's University Twickenham London

Ethics Application Form

1) Name of proposer(s)	Timothy Graham
2) St Mary's email address	134707@live.stmarys.ac.uk
3) Name of supervisor	Daniel Cleather

4) Title of project Autoregulated adjustments of intensity optimises maximal strength over a 12-week training cycle.

5) School or service	SHAS
6) Programme (whether undergraduate, postgraduate taught or postgraduate research)	MSc Strength and Conditioning Distance Learning

7) Type of activity/research (staff/undergraduate student/postgraduate student)	Postgraduate student

8) Confidentiality	
Will all information remain confidential in line with the Data Protection Act 1998?	YES

9) Consent	
Will written informed consent be obtained from all participants/participants' representatives?	YES

10) Pre-approved protocol	
Has the protocol been approved by the Ethics Sub-Committee under a generic application?	NO

11) Approval from another Ethics Committee	
a) Will the research require approval by an ethics committee external to St Mary's University?	NO
b) Are you working with persons under 18 years of age or vulnerable adults?	NO

12) Identifiable risks	
a) Is there significant potential for physical or psychological discomfort, harm, stress or burden to participants?	NO
b) Are participants over 65 years of age?	NO

c) Do participants have limited ability to give voluntary consent? This could include cognitively impaired persons, prisoners, persons with a chronic physical or mental condition, or those who live in or are connected to an institutional environment.	NO
d) Are any invasive techniques involved? And/or the collection of body fluids or tissue?	NO
e) Is an extensive degree of exercise or physical exertion involved?	YES
f) Is there manipulation of cognitive or affective human responses which could cause stress or anxiety?	NO
g) Are drugs or other substances (including liquid and food additives) to be administered?	NO
h) Will deception of participants be used in a way which might cause distress, or might reasonably affect their willingness to participate in the research? For example, misleading participants on the purpose of the research, by giving them false information.	NO
i) Will highly personal, intimate or other private and confidential information be sought? For example sexual preferences.	NO
j) Will payment be made to participants? This can include costs for expenses or time.	NO
k) Could the relationship between the researcher/ supervisor and the participant be such that a participant might feel pressurised to take part?	NO
l) Are you working under the remit of the Human Tissue Act 2004?	NO

13) Proposed start and completion date

Please indicate: • When the study is due to commence. • Timetable for data collection. • The expected date of completion. Please ensure that your start date is at least 3 weeks after the submission deadline for the Ethics Sub-Committee meeting.
The study is due to start 3 weeks after the submission deadline for the Ethics Sub-Committee meeting. Saturday 4th February 2017 will commence testing and familiarisation for participants, with the intervention programme commencing the week beginning February 6th 2017.

14)Sponsors/Collaborators
Please give names and details of sponsors or collaborators on the project. This does not include your supervisor(s) or St Mary's University. • Sponsor: An individual or organisation who provides financial resources or some other support for a project. • Collaborator: An individual or organisation who works on the project as a recognised contributor by providing advice, data or another form of support.
NA

15. Other Research Ethics Committee Approval

- Please indicate whether additional approval is required or has already been obtained (e.g. the NHS Research Ethics Committee).
- Please also note which code of practice / professional body you have consulted for your project.
- Whether approval has previously been given for any element of this research by the University Ethics Sub-Committee.

NA

16. Purpose of the study

In lay language, please provide a brief introduction to the background and rationale for your study. *[100 word limit]*

- Be clear about the concepts / factors / performances you will measure / assess/ observe and (if applicable), the context within which this will be done.
- Please state if there are likely to be any direct benefits, e.g. to participants, other groups or organisations.

The purpose of this study is to compare the effect of an autoregulated training programme (ARTP) versus a traditional periodisation model, on strength improvement in resistance trained athletes during a 12 week strength cycle (Matveyev., 1977; Plisk & Stone., 2003; Mann et al., 2010).

The traditional model or 'step loading' is characterised by intensification of workload each progressive microcycle (Stone et al., 1981; Zatsiorsky & Kraemer., 2006). However, because individuals respond to training stimuli at different rates, a possibility is that the use of autoregulated programme may optimise strength gain over a training cycle as it adjusts to the day to day variation in performance capabilities (Mann et al., 2010; Siff, 2000).

Mann, J. B., Thyfault, J. P., Ivey, P. A., & Sayers, S. P. (2010). The effect of autoregulatory progressive resistance exercise vs. linear periodization on strength improvement in college athletes. *The Journal of strength & conditioning research*, *24*(7), 1718-1723.

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Stone, M. H., O'Bryant, H., & Garhammer, J. (1981). A hypothetical model for strength training. *The Journal of sports medicine and physical fitness, 21*(4), 342.

17. Study Design/Methodology

In lay language, please provide details of:

a) The design of the study (qualitative/quantitative questionnaires etc.)
b) The proposed methods of data collection (what you will do, how you will do this and the nature of tests).
c) You should also include details regarding the requirement of the participant i.e. the extent of their commitment and the length of time they will be required to attend testing.
d) Please include details of where the testing will take place.
e) Please state whether the materials/procedures you are using are original, or the intellectual property of a third party. If the materials/procedures are original, please describe any pre-testing you have done or will do to ensure that they are effective.

A) The study is a randomised clinical trial, requiring quantitative data measuring the pre and post intervention one repetition maximum (1RM) in two strength training modalities (back and front squat).

B) The initial testing day will be utilised to collect each subject's biometric data and 1RM in back and front squat using previously reported methods (Haff and Tripnet, 2015). Before testing, all subjects will perform a dynamic warm-up consisting of back and front squat with incremental loading using an original IWF standard Eleiko Olympic bar and weights. Adequate rest will be required between efforts.

Following initial familiarisation day and pre 1RM tests, data will be collected and located in an excel spreadsheet. The participants will then be randomly assigned to one of two training programmes to adhere to for a 12 week period (traditional model versus autoregulated).

-Programming group one will be explicitly instructed- what to do. The intensity will be based on their absolute strength 1RM determined by the pre test and reps for each session will be prescribed. (For example 3 sets of 10 reps at 67.5% 1RM).

Programming group two will complete the same programme as group 1 with the -prescribed the number of sets and repetitions to perform each session. The intensity will not be disclosed, but the load will be determined subjectively. The participant will be required to choose a load that

promotes the feeling of having a required number of reps remaining in the hypothetical 'tank' (denoting effort). (Intensity will not be disclosed to athletes, it will be left to their own discretion).

For example a given sets prescription will be given with a subjective feeling of having "4 reps in the tank". Thus, the athlete could perform a further 4 repetitions if required to. The aim is that this exertion will be equivalent to a percentage of 1RM, but unknown to the athlete what the intensity will be until set is completed on that particular day (*see programmes in appendix*).

When results of programme have been completed statistical analysis will be performed using SPSS (version 21, IBM) and Microsoft Excel spreadsheet to present data. Pre test comparisons of subject characteristics will be performed using 2 tailed independent t-tests. Each training group will then be randomly divided into a 2 groups. A repeated measures ANOVA will be used to test for differences in squatting improvement where the within participants pre and post test scores and the between subjects factors of training group (Traditional verses ARTP). Effect sizes will be quantified by the calculation of partial $\eta 2$. An alpha level of $p < 0.05$ will be set for all testing.

C) Participants will be required to commit to two testing days interspersed by a 12 week programme, consisting of two training sessions per week (one back squat and one front squat).

D) The testing will take place at a privately owned Strength and Conditioning facility in Northern Ireland, County Down.

E) All materials and procedures will be original and owned by the National Weightlifting coach. No pre testing will be required due to the experience of the athletes that will be chosen to execute both front squat and back squat correctly.

Haff, G. G., & Triplett, N. T. (Eds.). (2015). *Essentials of Strength Training and Conditioning 4th Edition*. Human kinetics.

18. Participants

Please mention:

a) The number of participants you are recruiting and why. For example, because of their specific age or sex.
b) How they will be recruited and chosen.
c) The inclusion/exclusion criteria.
d) For internet studies please clarify how you will verify the age of the participants.
e) If the research is taking place in a school or organisation then please include their written agreement for the research to be undertaken.

A) Prospective calculation of power was performed using the Cohens method incorporating a Beta (β) 0.85, a standardised difference (SD) of 1.2 and a P value of <0.05 giving a final participant number of 12 per group (24 in total). However to account for participant drop out, an additional 30% will be recruited. Thus an additional 8 participants will be recruited giving a total of 32, establishing a final power of 0.85. The standardised difference (SD) was calculated using the equation X1 + x2 = d, X1 – x2\d =sd. X1 is the standard deviation before exercise, and x2 is standard deviation after intervention exercise (based on published data). D is then read off Cohen's chart for subject number.

B) All participants will know the correct technical model of front and high bar back squat (Haff and Tripnet, 2015). The participants will be recruited on the basis of training age, gender and bodyweight. Participants will be from Northern Ireland and have a minimum of 2 years resistance training experience. These participants must be able to squat below parallel and be able to squat at body weight or more. The back squat and front squat will be performed at full range of motion. The squat should be performed where the force is distributed to the hip and lumbar spine to minimise shearing force to knees (Escamilla, 2001 & Fry, Smith and Schilling 2003).

C) Participants must sign and return a consent form prior to testing and complete a physical activity readiness questionnaire (PAR-Q *see appendix*). Anyone who has an injury will be excluded from the study.
D) NA
E) NA

Escamilla, R. F. (2001). Knee biomechanics of the dynamic squat exercise. *Medicine and science in sports and exercise*, *33*(1), 127-141.

Fry, A. C., Smith, J. C., & Schilling, B. K. (2003). Effect of knee position on hip and knee torques during the barbell squat. *The Journal of Strength & Conditioning Research*, *17*(4), 629-633.

Haff, G. G., & Triplett, N. T. (Eds.). (2015). *Essentials of Strength Training and Conditioning 4th Edition*. Human kinetics.

19. Consent

If you have any exclusion criteria, please ensure that your 'Consent Form' and 'Participant Information Sheet' clearly makes participants aware that their data may or may not be used.

a) Are there any incentives/pressures which may make it difficult for participants to refuse to take part? If so, explain and clarify why this needs to be done

b) Will any of the participants be from any of the following groups?

- Children under 18
- Participants with learning disabilities
- Participants suffering from dementia
- Other vulnerable groups.

c) If any of the above apply, does the researcher/investigator hold a current DBS certificate? A copy of the DBS must be supplied **separately from** the application.

d) How will consent be obtained? This includes consent from all necessary persons i.e. participants and parents.

A) No
B) No
C) NA
D) Consent forms will be sent via email and returned before testing with the allocated amount of participants.

20. Risks and benefits of research/ activity

a) Are there any potential risks or adverse effects (e.g. injury, pain, discomfort, distress, changes to lifestyle) associated with this study? If so please provide details, including information on how these will be minimised.

b) Please explain where the risks / effects may arise from (and why), so that it is clear why the risks / effects will be difficult to completely eliminate or minimise.

c) Does the study involve any invasive procedures? If so, please confirm that the researchers or collaborators have appropriate training and are competent to deliver these procedures. Please note that invasive procedures also include the use of deceptive procedures in order to obtain information.

d) Will individual/group interviews/questionnaires include anything that may be sensitive or upsetting? If so, please clarify why this information is necessary (and if applicable, any prior use of the questionnaire/interview).

e) Please describe how you would deal with any adverse reactions participants might experience. Discuss any adverse reaction that might occur and the actions that will be taken in response by you, your supervisor or some third party (explain why a third party is being used for this purpose).

f) Are there any benefits to the participant or for the organisation taking part in the research (e.g. gain knowledge of their fitness)?

A) Yes, there will be low level risk for all participants. Physical training can produce muscle and skeletal trauma, thus generating a local inflammatory reaction. Low level discomfort as a result of delayed onset of muscle soreness will be experienced. Training will occur on non-consecutive days to minimise risk. The programme will have gradual increase of intensity to prepare the athlete each subsequent week of training.

In relation to unsupervised training, Myer (2009) reported that improper use of equipment was the dominant mechanism for injury among inexperienced athletes. Therefore, the prerequisite for the participants are to have a minimum of two years resistance training experience and correct lifting technique.

B) The primary risks will arise from participating in a weight lifting training programme, where low level muscle soreness an inherent consequence of lifting heavy loads. Participants will be required to implement the programme unsupervised for the duration of the intervention.
C) No
D) No
E) Adverse reactions to periodised programming will be referred to a medical practitioner depending on the severity of the reaction. If necessary the participant will be removed from the study to protect their welfare. The information explained from initial testing will present that each participant can leave the study at any time.
F) The participants will gain the ability of implementing a periodised strength programme and experience the physiological adaptations of a systematic training cycle. The appropriate findings from this study (individual pre and post 1RMs) will be given to each participant as well as the results of the study.

Angeli, A., Minetto, M., Dovio, A., & Paccotti, P. (2004). The overtraining syndrome in athletes: a stress-related disorder. *Journal of endocrinological investigation*, *27*(6), 603-612.

Myer, G. D., Quatman, C. E., Khoury, J., Wall, E. J., & Hewett, T. E. (2009). Youth versus adult "weightlifting" injuries presenting to United States emergency rooms: accidental versus nonaccidental injury mechanisms. *Journal of strength and conditioning research/National Strength & Conditioning Association*, *23*(7), 2054.

21. Confidentiality, privacy and data protection

a) What steps will be taken to ensure participants' confidentiality?

- Please describe how data, particularly personal information, will be stored (all electronic data must be stored on St Mary's University servers).
- Consider how you will identify participants who request their data be withdrawn, such that you can still maintain the confidentiality of theirs and others' data.

b) *Describe how you will manage data using a data a management plan.*

- *You should show how you plan to store the data securely and select the data that will be made publically available once the project has ended.*
- *You should also show how you will take account of the relevant legislation including that relating data protection, freedom of information and intellectual property.*

c) Who will have access to the data? Please identify all persons who will have access to the data (normally yourself and your supervisor).

d) Will the data results include information which may identify people or places?

- Explain what information will be identifiable.
- Whether the persons or places (e.g. organisations) are aware of this.
- Consent forms should state what information will be identifiable and any likely outputs which will use the information e.g. dissertations, theses and any future publications/presentations.

a) All data from each participant will be collected and stored on St Mary's University servers account electronically and the research project will be in line with the data protection act 1998. Each participant will be given an identification code number to their names accessed only by the study administrator under passcode and key security. If any participant wishes to be excluded then the papers will be terminated immediately.

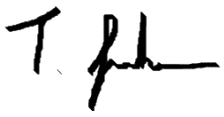
b) Participants will be protected by code with names attached to this code. This code will be how data is used and made public when the research study is completed. All data will be collected and stored on a password-protected computer known only by the research delegates on St Marys University servers.

c) Timothy Graham and Daniel Cleather.

d) No

22. Feedback to participants
Please give details of how feedback will be given to participants: • As a minimum, it would normally be expected for feedback to be offered to participants in an acceptable to format, e.g. a summary of findings appropriately written. • Please state whether you intend to provide feedback to any other individual(s) or organisation(s) and what form this would take.
Each participant will receive a summary of their own individual results alongside a summary of results for the study on a whole.

The proposer recognises their responsibility in carrying out the project in accordance with the University's Ethical Guidelines and will ensure that any person(s) assisting in the research/ teaching are also bound by these. The Ethics Sub-Committee must be notified of, and approve, any deviation from the information provided on this form.

Signature of Proposer(s) 	Date:04/12/2016
Signature of Supervisor (for student research projects) 	Date: 05/12/16

St Mary's University Twickenham London

Approval Sheet

Name of applicant: Timothy Graham

Name of supervisor: Daniel Cleather

Programme of study: MSc Strength and Conditioning

Title of project: Does autoregulation training have an effect on strength performance in resistance trained athletes over a 12 week cycle?

Supervisors, please complete section 1 or 2. If approved at level 1, please forward a copy of this Approval Sheet to the School Ethics Representative for their records.

SECTION 1

Approved at Level 1

Signature of supervisor (for student applications).....

Date.....

SECTION 2

Refer to School Ethics Representative for consideration at Level 2 or Level 3

Signature of supervisor.....  .....

Date.....05/12/16.....

SECTION 3

To be completed by School Ethics Representative

Approved at Level 2

Signature of School Ethics Representative.....

Date.....

SECTION 4

To be completed by School Ethics Representative. Level 3 consideration required by the Ethics Sub-Committee (including all staff research involving human participants)

Signature of School Ethics Representative.....

Date.....

Level 3 approval – confirmation will be via correspondence from the Ethics Sub-Committee

Appendix II

Participant Information Sheet

Autoregulated adjustments of intensity optimises maximal strength over a 12-week training cycle.

You are being invited to participate in a research study as part of an MSc dissertation. However, before you agree to take part it is vital that you understand why the research is being carried out and what will be involved in the study. Please take a few minutes to read the following information before deciding if you would like to take part in this study. If there are any questions please do not hesitate to ask.

Purpose and value of study

The purpose of this study is to compare the effect of autoregulated training programme (ARTP) verses a traditional periodisation model on strength improvement in resistance trained athletes during a 12 week strength cycle. The traditional model or 'step loading' is characterised by intensification of workload each progressive microcycle. However, because individuals respond to training stimuli at different rates, a possibility is that the use of autoregulated programme may optimise strength gain over a training cycle as it adjusts to the day to day variation in performance capabilities. Following initial familiarisation day and pre 1RM tests, participants will be randomly assigned to one of two training programmes to adhere to for a 12 week period (traditional model verses autoregulated). Participants will be required to commit to two testing days interspersed by a 12 week programme, consisting of two training sessions per week (one back squat and one front squat).

Who is organising the research?

An Msc student is organising the research and the research has been reviewed by a dissertation supervisor as well as an ethics committee.

What will happen to the results of the study?

The results will be published as part of an MSc postgraduate dissertation and possibly presented at a conference/published in a journal.

Source of Funding for the Research

There is no requirement for funding for this research.

Contact for further information

Timothy Graham

St Marys University

Waldergrave Road

Twickenham

TW1 4SX

Email: 137404@live.stmarys.ac.uk

Invitation – why I've been chosen to participate?

You have been chosen as a participants on the basis of a selection criteria. Participants are of similar abilities, training age, gender and bodyweight. All participants will be recruited from Northern Ireland and have a minimum of 2 years resistance training experience.

Can I chose not to take part or can I withdraw from the study?

If you decide to take part you will be given this information sheet to keep and asked to sign a consent form. You are free to withdraw from the study at any time.

What will happen if you agree to take part?

You will be required to participate in 12 weeks of strength training of exercise 2 times per week. Each day will require you to perform a warm-up that you would normally do in the gym. Loading strategy with differ and intensity will increase depending on what group you are selected in.

Whether there are any risks involved (e.g. side effects) and if so, what will be done to ensure your wellbeing/safety

Towards the final weeks of the programme you will be required to exert yourself, however the correct technical guidance will equip you with ways on how to load, unload and lose the bar safely.

Will agreeing to participate potentially compromise my legal rights?

This type of research will not compromise any of your legal rights if something were to go wrong.

Are there any safety precautions should I be beware of or any measures I should be taking before participating in this study?

No performance enhancing supplements should be taken during this study that could alter research results.

What will happen the results collected from you?

Results will be used to complete MSc dissertation project.

Are there any benefits in taking part?

As a participant of this study you will gain the ability to follow and implement a periodised strength programme and experience the physiological adaptations of a systematic training cycle. A summary of the findings of your individual results will be presented to you at the end of the study period.

How much time to I need to give up?

Commitment of 2 days per week for 12 weeks and an additional 2 days testing pre and post programme. Each session should last no longer than 75 minutes.

Will I be kept anonymous?

All information will be kept confidential.

YOU WILL BE GIVEN A COPY OF THIS FORM TO KEEP TOGETHER WITH A COPY OF YOUR CONSENT FORM

Appendix III

St Mary's University Twickenham London

Name of Participant: _____

Title of the project: Autoregulated adjustments of intensity optimises maximal strength over a 12-week training cycle.

Main investigator and contact details: Mr. Timothy Graham,

St Marys University

Waldergrave Road

Twickenham

TW1 4SX

Email: 134707@live.stmarys.ac.uk

Tel: 07894047998

Members of the research team:

1. I agree to take part in the above research. I have read the Participant Information Sheet which is attached to this form. I understand what my role will be in this research, and all my questions have been answered to my satisfaction.

2. I understand that I am free to withdraw from the research at any time, for any reason and without prejudice.

3. I have been informed that the confidentiality of the information I provide will be safeguarded.

4. I am free to ask any questions at any time before and during the study.

5. I have been provided with a copy of this form and the Participant Information Sheet.

Data Protection: I agree to the University processing personal data which I have supplied. I agree to the processing of such data for any purposes connected with the Research Project as outlined to me.

Name of participant
(print)……..

Signed……..……
Date…….....

If you wish to withdraw from the research, please complete the form below and return to the main investigator named above.

Title of Project: Does autoregulation training have an effect on strength performance in resistance trained athletes over a 12 week cycle?

I WISH TO WITHDRAW FROM THIS STUDY

Name: _____

Signed: _____ Date: _____

Appendix IV

RISK ASSESSMENT

Section 1 – Activity and Coordinator details:

Activity coordinator name:	Timothy Graham	Tutor / supervisor:	Daniel Cleather
Phone number:	07894046998	Email address:	134707@live.stmarys.ac.uk
Activity title:	Does autoregulation training have an effect on strength performance in resistance trained athletes over a 12 week cycle?		
Activity location(s) full details:	StrengthFarm, 32 Gransha Road, Rathfriland, BT34 5BX and various gym locations in Northern Ireland		

Outline of activity (please specify the type of activity being undertaken):	No	Yes	If yes, please provide details:
1. Use of Human Subjects: demographic type, requirements, age/young persons?		Y	19 – 35 year old resistance trained athletes
2. Use of an intervention (either solely or in combination) including dosage or application: E.g. ingestion of food, liquids or supplement, diet, massage, occlusion, environmental exposure, physical activity or other. Outline of specific dosage or application where relevant E.g. mg per kilo of body weight		Y	12 weeks of training protocol for front and back squat exercise. A % of intensity will be added each week with a small taper every 5th week before maximal testing takes place.
3. Use of data and/or sample collection (solely or in combination): E.g. questionnaire/survey, human tissue sampling (blood / urine / saliva / sweat or other), respiratory analysis, body composition, performance tests or other.		Y	Online spreadsheet (Google Sheets) shared to each participant's email account. The data will be kept private between myself and each participant
4. Use of chemicals/gas cylinders: Type(s), hazardous or not, MSDS available?	N		
5. Equipment to be used:			

Olympic weightlifting bar (Eleiko, Halmstad, Sweden), Olympic Plates (Eleiko, Halmstad, Sweden) and squat rack.

Assessment Reference No.		Activity assessed.	One repetition maximum of back and front squat.	
Assessment date	4/02/2017			
Persons who may be affected by the activity (i.e. are at risk)	Participants carrying out the study			
Brief description of activity/procedure	A) The initial testing day will be utilised to collect each subject's biometric data and 1RM in back and front squat using previous methods (Haff and Tripnet, 2015). Before testing, all subjects will perform a dynamic warm-up consisting of back and front squat using an original IWF standard Eleiko Olympic bar and weights.	Description of work to be done:	Please tick (✓) the following which applies:	
			Work to be done in designated areas	✓
			Work to be done under close supervision	✓
			Work to be done in the presence of at least 2 other workers	
			Work to be done within normal hours	✓
			Work not to be left unattended	

SECTION 1: Identify Hazard types - Consider the activity or work area and identify if any of the hazards listed below are significant.

1	Fall of objects		7	Heating, ventilation and humidity		13	Pressure vessels - autoclave		19	Biological hazards – micro-organisms, human samples or non-lab fieldwork		25	Working at heights	
2	Spillages, slips, Trips & Falls		8	Layout , storage, space, obstructions	✓	14	Noise or Vibration	✓	20	Fire hazards, flammable materials and explosion		26	Occupational stress	
3	Manual handling operations including repetitive movements	✓	9	Electrical Equipment	✓	15	Sharps – syringes, blades		21	Handling food		27	Violence to staff / verbal assault	
4	Display screen equipment		10	Physical hazards – electrical, temperature		16	Ergometers – rower, treadmill, bikes		22	Vehicles and driving		28	Lone working / work out of hours	
5	Work in public areas		11	Contractors		17	Ionising and non-ionising radiation		23	Physical Activity	✓	29	Confined spaces	
6	Lighting levels		12	Mechanical (machinery) and use of portable tools / equipment	✓	18	Chemical hazards – toxic, corrosive, flammables		24	Outdoor work		30	Other(s) - specify	

SECTION 2: Risk Controls - For each hazard identified in Section 1, complete Section 2. Please refer to the Risk Assessment Guidance notes on simmsCAPital folder for Risk Matrix. **Please note that L refers to Likelihood; S refers to Severity and RS refers to Risk Score (L times S equals RS)**

Hazard No.	Outcome due to Hazard description (Substance / equipment / procedure)	Initial risk Level (tick one) Refer to the risk matrix			Controls needed to eliminate or adequately reduce risks	Remaining Risk Level (tick one)		
		High (13-25)	Med (5-12)	Low (0-4)		High (13-25)	Med (5-12)	Low (0-4)
3	Manual handling operations including repetitive movements			4	All weights must be taking off and put on using appropriate lifting techniques			4
8	Accident due to obstructions		6		Maintain storage of all items in relevant cupboards / spaces Use wire covers on flooring or cable trunking or hazard tape for loose cables			4

9	Electrical Equipment		6		□ Annual PAT checks carried out. Specific training provided □ Equipment inspected frequently including before the start of each session □ Do not connect multiple extension leads together. □ Ensure all electrical equipment is turned off or put in stand-by where relevant (e.g. Biosen) at close of day			4
12	Use of portable equipment		7		□All users must have received adequate training to use the equipment □ All users where PPE where appropriate □ Sampling kits, samples and carriage should be labelled with appropriate Hazard signs			4
14	Noise or vibration		10		All participants must complete a PAR-Q and have no preexisting health issues prior to taking part in the study			4

23	Physical activity		9		All relevant equipment inspected and calibrated before the start of the testing session Ensure the participant is aware of the testing protocol and the associated risks (a written protocol should be provided) Ensure participant(s) has completed and signed an approved St Mary's Informed consent form and Par-Q prior to commencing any physiological testing procedure Ensure the participant completes an appropriate warm-up prior to sub-maximal and maximal tests Ensure the subject withdraws from the exercise if they feel they cannot maintain the required power-output or if they experience feelings of faintness or nausea Any faults or maintenance issues reported to a member of technical services staff. If			4

					an accident occurs the participant will fill out an accident report form (depending on severity) to be documented in case of further investigation. A first aider will be present during testing, or if necessary participant will be referred to hospital.			

SECTION 3: Action Plan in the event of an emergency - For each hazard identified in Section 2, complete Section 3.

- Please refer to the Risk Assessment Guidance.

Hazard Number	Hazard Description – Substance / equipment / procedure	Action required (describe)
3	Manual handling operations including repetitive movements	Apply relevant First Aid and seek Medical Assistance where appropriate
8	Accident due to obstructions	Apply relevant First Aid and seek Medical Assistance where appropriate
9	Electrical Equipment	Apply relevant First Aid and seek Medical Assistance where appropriate
12	Use of portable equipment	Apply relevant First Aid and seek Medical Assistance where appropriate

14	Noise or vibration	Apply relevant First Aid and seek Medical Assistance where appropriate
3	Manual handling operations including repetitive movements	Apply relevant First Aid and seek Medical Assistance where appropriate
8	Accident due to obstructions	Apply relevant First Aid and seek Medical Assistance where appropriate
23	Physical activity	Apply relevant First Aid and seek Medical Assistance where appropriate

SECTION 4: Arrangement for supervision and/or monitoring effectiveness of control

- For each hazard identified in Sections 2/3, complete Section 4.

- Please refer to the Risk Assessment Guidance notes.

Hazard No.	Hazard Description – Substance/equipment/procedure	Comments
3	Manual handling operations including repetitive movements	Monitoring achieved through pre and post checks, continual peer communication and/or separately recruited individual where further supervision is required.
8	Accident due to obstructions	Monitoring achieved through pre and post checks, continual peer communication and/or separately recruited individual where further supervision is required.
9	Electrical Equipment	Monitoring achieved through pre and post checks, continual peer communication and/or separately recruited individual where further supervision is required.

12	Use of portable equipment	Monitoring achieved through pre and post checks, continual peer communication and/or separately recruited individual where further supervision is required.
14	Noise or vibration	Monitoring achieved through pre and post checks, continual peer communication and/or separately recruited individual where further supervision is required.
3	Manual handling operations including repetitive movements	Monitoring achieved through pre and post checks, continual peer communication and/or separately recruited individual where further supervision is required.
8	Accident due to obstructions	Monitoring achieved through pre and post checks, continual peer communication and/or separately recruited individual where further supervision is required.
23	Physical activity	Monitoring achieved through pre and post checks, continual peer communication and/or separately recruited individual where further supervision is required.

SECTION 5: Further comments – If a more complex assessment is required, continue below:

IMPORTANT CONTACT DETAILS (including where activities are undertaken off campus):

St Mary's University College Security – 0208 240 4335 (advise in the event of calling the emergency services)

Health and Safety Executive (HSE) Information line – 0845 345 0055 / www.HSE.gov.uk

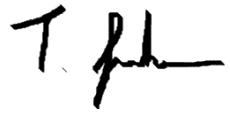
StrengthFarm Strength & Conditioning Facility - 07894046998

GUIDELINES FOR REFFERAL (as a hard copy attachment, listed web link or other source):

(Examples of supporting information could be a Material Safety Data Sheet (MSDS) or a Qualification/Accreditation guideline).

SECTION 6: Period of cover – If a more complex assessment is required, continue below:

By signing this risk assessment I confirm that I have read and understood all of the risks associated with the activity specified on sheet 1, and that I will follow all of the specified controls to reduce the risks identified with the activity.

PERIOD OF COVER FOR TASK/EVENT		PRINT NAME OF TASK/EVENT LEADER	SIGNATURE	DATE SIGNED	HAZARDS IDENTIFIED (mark with a tick or a cross)
FROM	TO				
December 2016	May 2017	Timothy Graham		4/12/2016	X

Appendix V

St Mary's University Twickenham London

SCHOOL OF Sport, health and applied science

CONFIDENTIAL Medical History / Physical Activity Readiness Questionnaire (PAR-Q) FORM

This screening form must be used in conjunction with an agreed Consent Form.

Full Name: _____ Date of Birth: _____

Height (cm): _____ Weight (kg): _____

Have you ever suffered from any of the following medical conditions? If yes please give details:

	Yes	No	Details
Heart Disease or attack	☐	☐	_____
High or low blood pressure	☐	☐	_____
Stroke	☐	☐	_____
Cancer	☐	☐	_____
Diabetes	☐	☐	_____
Asthma	☐	☐	_____
High cholesterol	☐	☐	_____

Epilepsy ☐ ☐

_____

Allergies ☐ ☐

_____

Other, please give details ☐ ☐

_____

Do you or have your family suffered from any form of deep vein thrombosis / blood clots. If yes please give details;

Please give details of any medication you are currently taking or have taken regularly within the last year:

Please give details of any musculoskeletal / orthopaedic injuries you have had in the past 12 months which have affected your capacity to exercise or caused you to take time off work or seek medical advice:

Other Important Information

During a typical week approximately how many hours would you spend exercising?

If you smoke please indicate how many per day:

If you drink alcohol please indicate how many units per week:

Are you currently taking any supplements or medication? Please give details:

Is there any reason not prompted above that would prevent you from participating within the relevant activity?

By signing this document I agree to inform the relevant individual(s) of any change(s) to my circumstances that would prevent me from participating in specific activities.

Signature (Participant): Date:

Signature (Test Coordinator*):

*Test coordinator: The individual responsible for administering the test(s)/session

Appendix VI

The new rating scale constructed as a category scale with ratio properties by Borg (1982).

Rate of Percieved Exertion	
0	Nothing at all
0.5	Very, very light
1	Very light
2	Light
3	Moderate
4	Somewhat heavy
5	Heavy
6	
7	Very heavy
8	
9	
10	Very, very heavy
*	Maximal

Borg, G. A. (1982). Psychophysical bases of perceived exertion. *Med sci sports exerc*, *14*(5), 377-381.

Appendix VII

Position	Description.
Start	Hands placed shoulder width apart on bar. Bar positioned across upper trapezius and rear deltoids, just below C7 in high bar. (*Front Squat difference was that the bar sits on the front deltoids with elbows pointing forwards.) Athlete stands with extension through spine, supported by the hips and knees-bracing musculature. Feet are positioned with toes slightly pointing outwards and just outside shoulder width.
Descent	A diaphragmatic breath is taken at the start. With a slight anterior lean of the trunk, the hips are unlocked and flexion of the knees begins. Knees and hips are flexed until the femur is parallel with the floor, with the hips behind heels. Feet remain flat throughout. Knees maintain alignment over the toes, going beyond them in the sagittal plane. An anterior trunk lean is maintained throughout the movement, whilst maintaining lumbar lordosis and thoracic rigidity.
Ascent	The feet are forcefully driven into floor. Extension of the knees and hips. The knees remain in position over toes in coronal plane. The bar and hips raise at the same tempo. Extension of the thoracic and lumbar lordosis maintains the spinal curvature throughout. A breathe out is performed through mid-range of movement.

Failing Safely	A clear space behind the athlete is required. If the athlete is unable to complete the ascent, a violent and simultaneous pushing of the bar backwards with the hands must occur. The athlete aggressively jumps forward, and upwards, extending though the hips and trunk. The athlete must maintain an upright torso at the base of the squat in order to complete failing safely.

6

7 Table 6. Overview of the back squat technique (44).